An Integrated Assessment for the Sustainable Use of Forest Ecosystems and Biodiversity

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6.1. Introduction

In this chapter, we propose a methodology for the integrated assessment of sustainable use of forest ecosystems and biodiversity. This assessment is a synthesis of the project results, including the history of forest use, changes in biodiversity and ecosystem services, and socioeconomic mechanisms behind them, which are presented in Chapters 2 to 5.

The aims of the integrated assessment are (1) to evaluate the sustainability of the utilizations of forests and biodiversity by analyzing historical changes in the target regions; (2) to estimate the future forests, biodiversity, and ecosystem services under various scenarios; and (3) to provide possible policy and management options to decision-makers. Every region has specific conditions, and people in those regions make decisions about future forest uses according to the information they have. Our goal in creating this assessment was to provide decision-support tools as well as potential options and their projected consequences.

6.2. Steps in the assessment

6.2.1. Overall process

The assessment process includes the following steps: (1) analyze historical changes in forest use, (2) identify and quantify the driving forces responsible for the changes, (3) analyze the consequent changes in biodiversity and ecosystems, and (4) evaluate the effects of biodiversity on ecosystem services. Through these four steps, we can evaluate how past changes in forest use and biodiversity have affected ecosystem services. We can also identify the types of forest use that caused specific changes in biodiversity and ecosystem services. The assessment has two additional steps: (5) evaluate existing institutions that operate to utilize forest ecosystems and biodiversity in sustainable ways, and (6) propose future forest uses, including potential options and the projected consequences (Fig. 1). The first four steps are well documented in Chapters 2 to 5. In this chapter, we focus on the final two steps.

6.2.2. Historical changes in forest use

As documented in Chapter 2, past forest conditions can be detected using land-use maps, aerial photographs, satellite images, and other related tools. The changes in forest use can then be summarized into transition matrices and analyzed quantitatively.

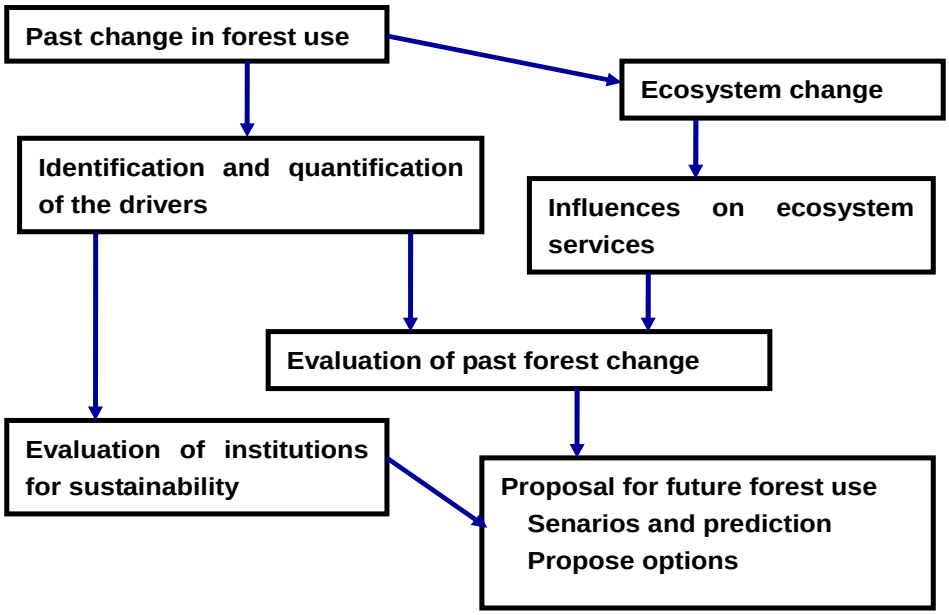

Figure 1. The process of the integrated assessment for sustainable use of forest ecosystems and biodiversity.

6.2.3. Identification and quantification of the driving forces

The drivers that caused the changes in forest and land use were identified by analyzing published literature, statistics, and historical records (Chapter 2). Some cells in the transition matrices were attributed to particular drivers. It may be possible to assign more transition probabilities to identified drivers if we subdivide the matrices into those of different land owners, actors, and so on. Using transition matrices with identified drivers, we were able to project the future land use (see below). These changes were also visualized as maps, which are useful decision-making tools.

6.2.4. Ecosystem and biodiversity changes

As shown in Chapter 3, we can evaluate the diversity of various taxa using classified forest types. Some species or taxa respond very sensitively to forest type, whereas others do not. Although an analysis of the biological responses is still in progress, several species and taxa seem to be very promising as reliable indicators of ecosystem function. These detailed analyses will provide information about index species or taxa for particular forest types, ecosystem functions, and ecosystem services.

It is possible to visualize the biodiversity of particular species or taxa by using maps that combine a diversity index and forest type. If we know that a species is a very good indicator of some ecosystem function, we can also show the spatial distribution of a particular ecosystem function. An example is shown in Figure 2. In this case, the diversity of wood-destroying fungi declined between 1962 and 1997.

6.2.5. Evaluation of ecosystem services

The ecosystem services provided by biodiversity are very difficult to evaluate. Few of them are economically appreciated, and the causal associations between biodiversity and ecosystem services are

sometimes very weak. However, some ecosystem functions are closely related to biodiversity, such as pollination and pest control. If we can detect the relationships between forest type and diversity or between forest type and abundance of species or taxa, we can map the ecosystem services. An example is shown in Figure 3. In this case, the abundance of braconid parasitoids that control harmful insects decreased between 1962 and 1997.

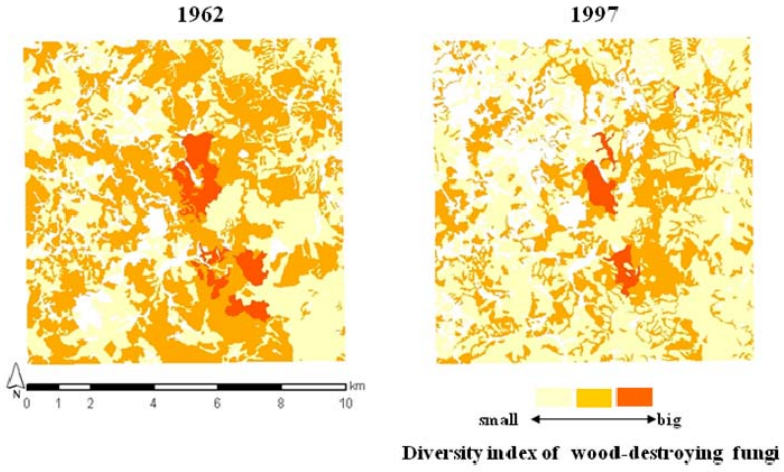

Figure 2 Ecological function map of wood-destroying fungi at Abukuma (Miyamoto et al. unpubl.).

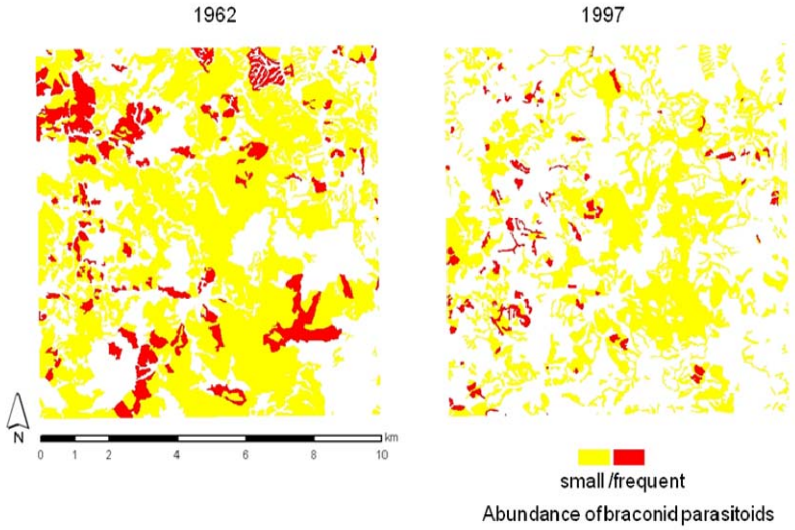

Figure 3 An ecological service map of braconid parasitoids at Abukuma. (Miyamoto et al. unpubl.).

6.2.6. Evaluation of past forest use as a whole

Following the procedures listed above, we were better able to understand how forests in a target region changed, how these changes affected the biodiversity and ecosystem, and how such changes in biodiversity affected ecosystem services. We were able to quantitatively analyze a change and its drivers through the use of a transition matrix and also able to visualize the changes in forest use, biodiversity, ecosystem functions, and ecosystem services on maps.

To increase the practical applicability of this assessment, we sometimes needed to create scenarios of future changes and then show the consequences of the changes. Examples of such projections are shown for land use (Fig. 4) and ecological function (Fig. 5) and services (Fig. 6) in Abukuma. The scenarios used in these examples are as follows: (1) continuation of present trends; (2) restoration of Satoyama—20% of coniferous forests are converted to broadleaf forests, no broadleaf forests are converted to coniferous forests, and 20% of broadleaf forests are converted to grassland; and (3) logging is conducted with a long period between cutting—10% of coniferous forests and broadleaf forests are not logged to help create old forests, and the cutting periods are 100 years for broadleaf forests and 80 years for coniferous forests.

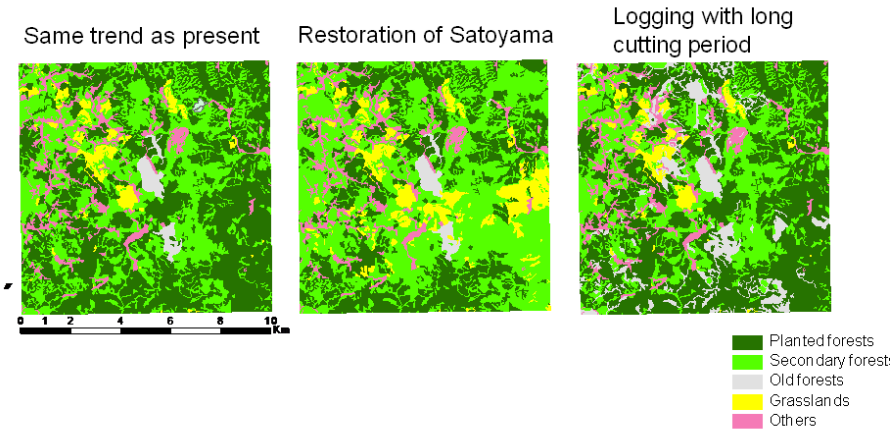

Figure 4 Projections of land use in 2017 under three scenarios in Abukuma (Miyamoto et al. unpubl.).

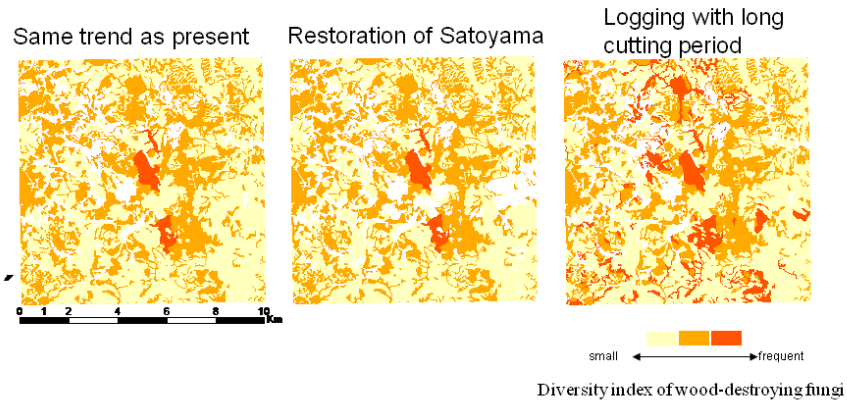

Figure 5 Projections of an ecological function in 2017 under three scenarios in Abukuma (Miyamoto et al. unpubl.).

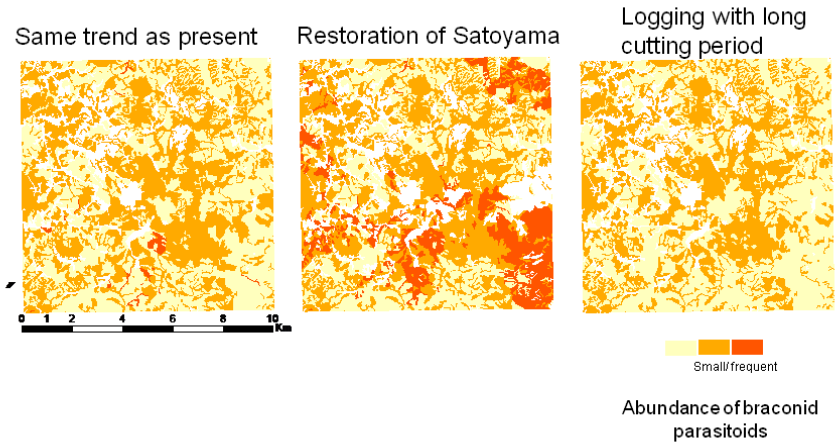

Figure 6 Projections of an ecological service in 2017 under three scenarios in Abukuma (Miyamoto et al. unpubl.).

6.3. Evaluation of institutions for sustainable use

In the rest of the chapter, we describe the final two steps of the assessment. It is necessary to evaluate existing institutions to understand a region's sustainable use of forests. As we use it, the word "institution" covers a wide range, from local to global. Institutions, in this sense, include unwritten and written rules of local communities, regional or national laws, trading mechanisms, international conventions, and ways of thinking.

Our evaluation of the institutions had two stages: one was to evaluate an institution's goals and

expected effects, and the other was to evaluate its effectiveness in reaching those outcomes.

6.3.1. The aims of the institutions

The definitions of sustainability vary greatly, sometimes depending on what kinds of ecosystem services the stakeholders want to maximize. Considering both past published research and that presented in this volume, we used the following criteria to evaluate the aims or expected effects of institutions. Because the types of ecosystem services are sometimes not consistently described within an institution, we classified the ecosystem services into roughly three types (timber, food, and Non-Timber Forest Products (NTFPs)), according to the Millennium Ecosystem Assessment (2005). Each institution was first evaluated on the basis of whether it includes the following aims.

1. *Provisioning services*: Does the institution aim to sustain provisioning services, such as timber, foods, and NTFPs?
2. *Regulating services*: Does the institution aim to preserve regulating services, such as water quality, soil conservation, pest control, and pollination?
3. *Cultural services*: Does the institution aim to preserve cultural services, such as spiritual, educational, and artistic benefits from the ecosystem?
4. *Un-substitutable resource conservation*: Does the institution aim to avoid the exhaustion of resources for which there is no substitute (i.e., strong sustainability and pre-cautious principle)?
5. *Geographical evenness*: Does the institution aim to share the benefits in a geographically "even", that is, fair way (e.g., benefits are not biased towards only developed countries)?
6. *Evenness beyond generations*: Does the institution aim to keep an even share of benefits for future generations (*sensu* G.H. Brundtland)?

From the perspectives of sustainable use and conservation of biodiversity, we also propose the following criteria.

7. *Genetic diversity*: Does the institution aim to preserve genetic diversity of the resource species or target ecosystem?
8. *Stable species composition*: Does the institution aim to preserve a stable species composition?
9. *Stable ecosystem*: Does the institution aim to preserve stable ecosystem functions (even if the species composition does change)?
10. *Biological uniqueness and rarity*: Does the institution aim to conserve rare or regionally unique species or ecosystems?

6.3.2. Effectiveness of institutions

Some institutions operate more effectively than others, irrespective of their aims. We had intensive discussions among the project members about the effectiveness of institutions and what factors actually determine effectiveness. Based on these discussions, we first evaluated whether an institution worked effectively or not. We then examined the institutions to identify the key criteria for effectiveness. These criteria are summarized below:

1. *Distinctiveness of rights*: Resource sustainability can be lost if the rights to use the resources are not clearly defined. For example, a governor may sell the right to log a tropical forest to an outside entity even though local residents insist on their traditional right to use the forest.
2. *Incentives for governors or managers*: Some institutions are not effective because the people who run the institutions do not have appropriate incentives to maintain the institutions.
3. *Incentives for users*: Some institutions do not work effectively because the users—the people who receive the ecosystem services—do not have any incentive to maintain sustainability.
4. *Punishment*: It is likely that some institutions operate more effectively because they punish people who do not follow the rules.
5. *Mismatched scales*: In some cases, the ecosystem service users are local in scale, whereas those who create the rules or manage the system are from a larger-scale institution (e.g., a government or international agency). Sometimes, the people who pay for the ecosystem services are not exactly the same as users. Ecosystem services may be received globally, but only local residents pay the social costs to keep the ecosystems functioning in a sustainable manner. Such mismatches in spatial scale among the users, managers, and payers lead to ineffective institutions.

6.3.3. Evaluation of the existing institutions

We evaluated 64 existing institutions (Table 1), which were classified as public institutions and policies; international aids; activities by citizens, enterprises, or NPOs; ranking; and thought. Each institution was evaluated based on the 10 criteria of aims and 5 criteria of effectiveness, as well as based on effectiveness itself.

Several general trends can be seen from our evaluation. Some international conventions related to biodiversity (e.g., Convention on Biological Diversity (CBD)) show rather comprehensive coverage of aims, but they are not very effective. Institutions for assigned geographic areas (e.g., national parks and forest reserves) tend to cover the biodiversity aims and many criteria of sustainable forest use, but not provisioning services. The institutions that have aims in sustainable provisioning services usually do not meet the biodiversity criteria. Many institutions at the community level do not include the biodiversity criteria.

In terms of effectiveness, general trends can also be seen. The effective institutions have clearly defined distinct rights. Many effective institutions have high incentives for governors and use punishment. The users, managers, and cost payers of effective institutions tend to be on the same scale, and most of the effective institutions are local or regional in scale. We did not find global institutions with high levels of effectiveness.

6.4. Assessment application

We applied our assessment to the four project sites. First, we summarized each area's problems concerning sustainability of forest use and biodiversity and examined the natural, social, economic, and cultural environments at each site (Table 2). We then extracted the key issues for sustainable forest use for each site, and we evaluated the aims and effectiveness of the existing institutions at each site (Table 3). Finally, we made recommendations to solve the key problems.

6.4.1. Abukuma Mountains (Japan)

<History>

The site includes large National Forest areas. From the time of the Tokugawa administration until the 1960s, horses for military use were produced in grasslands in this area. National Forest policy then shifted, and coniferous plantations increased while grasslands and natural forests rapidly decreased. At the same time, the fragmented natural forest was designated as either a Forest Preservation Area or Protected Area of the Prefecture. Secondary forests around residential areas had been managed for fuel production with the collaboration of the local community and National Forest managers. As fuel demand decreased, the timber from secondary forests has been used for mushroom production. Common grasslands existed until the 1990s, but they have since been divided into privately owned plots.

<Key issues >

Protected natural forests play an important role as habitat for locally unique or rare plants and animals. The recent decrease in coniferous forests has made it difficult to manage plantation forestry in a sustainable way. Secondary forests are important for the conservation of local flora and fauna, but successful collaboration is required between the local community and National Forest managers.

<Evaluation >

Although the area has been extremely fragmented, the natural forests are well protected. Since the Natural Forest covers a large area, its policies have significant influence on forest management, including on private secondary forests. The present system, however, does not work effectively except for provisioning services (timber). The manager’s incentives are low. Cultural services and biodiversity conservation are generally not included or effectively managed in the traditional agroforestry management system (Satoyama). Traditional community management, which had been at least partly effective, is no longer used because there are few user incentives.

<Recommendations>

Increasing the sustainability and biodiversity conservation of coniferous plantations and secondary forests must be prioritized. The incentives of resource users in both the plantations and secondary forests must be increased. Recently, subsidies have been offered for sustainable forestry and environmentally conscious agriculture, but the effectiveness of these programs is not yet clear.

6.4.2. Yaku Island (Japan)

<History>

National Forest policies for Yaku Island have caused natural forests to decrease greatly while, at the same time (1960 to 1970), coniferous plantations increased rapidly. Secondary broadleaf forests, which had provided fuel, were commonly used by local communities with the consultation of the National Forest. These secondary forests were also converted into coniferous plantations, and such collaboration between the National Forest and the local communities diminished. During 1950s and 1960s, old *Cryptomeria* trees were designated as Natural Monuments and parts of the island was designated as a National Park. The people who immigrated to the island played an important role in the nature conservation movement. After Yaku Island was designated as a World Heritage Site in 1992, tourism (including ecotourism) became increasingly

popular, but there has been some overuse of parts of the ecosystem. The amount of agricultural damage caused by wild monkeys and deer has recently become a serious problem.

<Key issues >

It is important to protect natural forests for their ecosystem services, as well as for ecotourism. *Cryptomeria* trees (including old-growth trees) should be managed in a sustainable way both for resources and for ecotourism. Secondary broadleaf forests play an important role in maintaining biodiversity around residential areas, although they seem to be unused. The agricultural damage caused by wild animals should be solved.

<Evaluation >

Because areas in the central part of the island are designated as either National Park or as a World Heritage Site, or are protected by other institutions, the forest ecosystems and biodiversity are sustainably used, primarily for tourism. However, overuse and an uneven distribution of the benefits from ecotourism have become problems in some areas. The local and social costs associated with regulation are increasing. A scale mismatch is one of the causes of these problems. Old-growth *Cryptomeria* wood is no longer available, and wood harvested from plantations does not have the same value. The timber value of the island's forests is lower than that of other regions in Japan, which reduces incentives for the plantation owners. The local community has also lost the incentive to manage the secondary broadleaf forests because the wood is no longer used as fuel, and many of these forests have been converted into plantations. This has led to a loss of biodiversity and local culture, but ecotourism has started to utilize some secondary forests. The rapid increase in plantations combined with the decrease in broadleaf forest seems to be one of the reasons for the increased amount of agricultural damage caused by wild mammals. Increasing the amount of broadleaf forest is considered to be a measure that could solve this problem, but effective institutions would have to promote this. Many scientific studies have been conducted on this island, and they have played roles in enhancing the recognition of ecosystem services and incentives for the sustainable use of forest ecosystems and biodiversity.

<Recommendations>

Institutions need to enhance incentives for managers and users of secondary forests and plantations. An example of a possible solution is promoting the use of forest products using World Heritage brands. Filling the scale gaps between users and cost payers, such as instituting an island entrance fee, could improve the overuse situation. Subsidies for sustainable forestry or environmentally conscious agricultural practices may increase the incentives of users, but their effectiveness has not yet been evaluated.

6.4.3. Kinabaru and Deramakot, Sabah (Malaysia)

<History>

The area around Kinabaru Mountain was protected as both a National Park and a World Heritage Site. Because of the cool climate, some areas have also been developed for intensive vegetable cultivation. In addition, golf course, sericulture, and tourism have also been developing in this area, all of which act to reduce the area of primary mountain forests near the border of the National Park.

In the Deramakot area, commercial logging has been intensively conducted since the 1970s, and few

primary forests remain. A reduced-impact logging system was introduced in the late 1980s, and the area received certification from the Forest Stewardship Council (FSC) in 1997.

<Key issues >

The primeval mountain forest around Kinabaru is valuable for ecosystem services in this region, including ecotourism and local culture. The balance between natural forest conservation and agricultural development is the key issue. An evaluation of the reduced-impact logging system in terms of biodiversity is necessary in the Deramakot area.

<Evaluation >

The World Heritage Site and National Park have operated to maintain incentives for both local residents and the local government by providing benefits through ecotourism. Local environmental education has been effective in enhancing the recognition of the importance of ecosystem services and forest conservation. Overuse has recently become an issue. Agricultural development around Kinabaru National Park has been rapid, and there are few effective institutions to regulate the cultural ecosystem services and biodiversity.

The government leased the land for reduced-impact logging with a 90-year contract, and this long-term contract enhanced the users' incentives for sustainably using the forests. Certification by the FSC requires a dialog with local residents; thus, it has played a role in enhancing incentives for geographical evenness.

<Recommendations>

Economic and institutional regulations are necessary to avoid overuse in Kinabaru National Park. Incentives must be provided to local residents to avoid further development around the park. Bringing local culture and products into the ecotourism scheme is a possible way to provide incentives. Reduced-impact logging in Deramakot remains an issue that has local social impacts.

6.4.4. Lambir Hills, Sarawak (Malaysia)

<History>

The Lambir Hills area was covered by primeval forests until the early 1900s. When the Iban colonized the area, they began to convert the forested areas to agricultural production. Some economic activities, such as commercial logging, rubber production, and commercial rice production, have caused rapid changes in land use. The lands owned by the Sarawak State have been rapidly and intensively converted into oil palm plantations since the late 1970s. Commercial logging was started in 1960s and became rapid in 1970 and 1980s. A 7000-ha area was designated as National Park in 1974.

<Key issues >

The forest in the National Park is a valuable remnant of the natural forests in this region, but the area is too small for animals with large home ranges. Traditional land uses, which now depend on the natural recovery of secondary forests, have declined recently. Commercial logging is still conducted, but some sustainable management practices have been introduced. The increase in oil palm plantations has caused a rapid decrease in biodiversity.

<Evaluation >

Rights are relatively clearly defined through both National Park policy and land ownership in this region.

The National Park system lacks local incentives, but frequent patrols and punishment of violators of the rules ensures some protection. Illegal logging and hunting still occur in the park, but these activities are small in scale. The lack of incentives for local residents to continue the traditional agroforestry system has led to an increased amount of land being converted into oil palm plantations. This may lead to a rapid loss in sustainability and biodiversity. NGOs have worked to increase local incentives for provisioning NTFPs and cultural services.

<Recommendations>

Traditional land uses are not very effective in maintaining biodiversity, but they are much better than the large-scale development of oil palm plantations. A combination of traditional land uses and National Park management may be more effective. That, however, would require incentives for local people to keep traditional land uses. Eco- and/or cultural tourism, which have recently been introduced in other regions of Sarawak, may provide such incentives. Domestic certification of sustainable forest management has also been recently introduced, but it is not as effective in maintaining sustainability as the FSC system. The geographical evenness of oil palm plantations and commercial logging need to be regulated.

6.5. Further development of the assessment system

Our proposed assessment system has several implications. First, the historical analysis provides useful information for evaluating future options. It is necessary to identify and quantify the driving forces responsible for forest change to project the consequences of future changes under the given scenarios. An algorithm to detect the effect of such changes in forest use on biodiversity and ecosystem functions was also developed in this project. The maps that show historical changes in biodiversity allowed us to evaluate what past forest changes have meant in terms of biodiversity and sustainability.

The evaluation methods for ecosystem services associated with biodiversity are vague and difficult to include in the assessment. However, the methods used in this project have shown some promise, especially through the use of spatial maps. Thus, through the use of scenarios of future land use or forest policy, it will be possible to present options to decision- makers.

Some new institutions may need to be introduced to ensure sustainability and biodiversity. In this case, the system of evaluating existing institutions explained in this chapter could be a useful tool. In the discussion up to now, partly because of the variety in definitions of sustainability, ecosystem services and the aspects of sustainability that an institution aims to maintain have not been clear. The first step of the evaluation is to clearly define the ecosystem services and institutional aims.

We also evaluated the effectiveness of institutions. We may be able to improve the effectiveness of existing institutions by identifying current problems and discuss the possibility of introducing new institutions as needed. Our system enables us to identify what institutions fit a given situation in the target region.

However, there are still several issues that require further development. First, we need to develop methods of quantifying the driving forces that are responsible for forest change in more detail. Otherwise, the projections developed will not be useful enough. We also need to develop good indicators for some ecosystem functions or services. If we succeed in finding such indicators, the options presented in our

projections will be more informative. In particular, the evaluation of ecosystem services requires intensive study. The present knowledge of the types of ecosystem services associating with biodiversity is still limited. The evaluation of institutions for sustainable use also remains under discussion. The effectiveness of these institutions varies among regions, natural conditions, traditional cultures, and schools of thought. Detecting the causes of such variation is another challenge.

The system we have proposed is a starting point to develop assessment methods, and there is still a rather long way to go for the practical application of such methods. However, we think that the framework to approach such an assessment method has been made clear.

Reference

Millennium Ecosystem Assessment (2005) Ecosystem & Human Well-being. Island Press: Washington D.C.

Table 1 Evaluation of existing institutions for forest uses and biodiversity

Classification	Institution	Sustainable forest use						Biodiversity conservation				Effectiveness of institutions	Factors relevant to effectiveness							Comments
		Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
public institutions and policies	Protected area		○	○	○		○	○	○	○	○	○	○	○	○	○	R/G	L/R/G	L/R	
public institutions and policies	MAB Plan		○	○	○		○	○	○	○	○	○					R	L/R/G	L/R	
public institutions and policies	National Parks in Japan		○	○	○		○	○	○	○	○	○	○	○		○	L/R	L/R/G	R	
public institutions and policies	National Parks in Thailand		○	○	○		○	○	○	○	○			○		○	L/R	L/R/G	L/R	
public institutions and policies	National Parks in Sabah		○	○	○		○	○	○	○	○	○		○	(○)	○	L/R	L/R/G	L/R	There are both successful and unsuccessful cases using incentives.
public institutions and policies	National Parks in Indonesia		○	○	○		○	○	○	○	○					(○)	L/R	L/R/G	L/R	
public institutions and policies	Protected forest by Forest Agency of Japan		○	○	○		○	○	○	○	○	○	○				R	L/R	R	
public institutions and policies	Ideal National Park						○					○	○	○	○	○		L/R/G	L/R/G	How incentives are given to forest managers and users should be examined.
public institutions and policies	World Heritage			○	○		○				○	○	(○)	○	(○)	○	L/R	L/R/G	L/R/ (G)	Management is done by each national law and regulation, so vary depending on nations
public institutions and policies	Ramsar Convention						○	○		○	○	(○)		○			L/R/G	L/R/G	L/R/G	The areas are designated where proper regulations are established.
public institutions and policies	Bonn Convention						○	○		○	○	(○)		○			L/R/G	L/R/G	L/R/G	
public institutions and policies	Natural Treasure (place)			○	○		○				○	○	○	○	(○)	○	L/R	L/R	L/R	Effectiveness varies depending on region.

Classification	Institution	Sustainable forest use: Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Biodiversity conservation: Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity	Effectiveness of institutions	Factors relevant to effectiveness: Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	Comments
public institutions and policies	Satoyama conservation areas	○	○	○			○				○	?	○	○	○		L	L/R	L/R	Not effective without subsidies.
public institutions and policies	Subsidies to lower mountainous regions	○	○	○				○		○		?	○	○	○		L	L/R	L/R	Effectiveness is not yet known because the system has just started.
public institutions and policies	Prevention of intrusion of exotic species	○	○	○	○		○	○	○	○	○	○	—	○		○	L/R	L/R	L/R	Conflicts among users exist.
public institutions and policies	Urging natural rehabilitation		○	○			○			○	○	?	○	○	○		L/R	L/R	L/R	Effectiveness is not yet known because the system has just started.
public institutions and policies	Natural Treasure (species)			○	○		○		○		○	○	○	○		○	L/R	L/R	R	
public institutions and policies	Species protection				○		○	○	○		○	○	○	(○)		○	L/R	L/R	L/R	
public institutions and policies	Environmental impact assessment		○	○	○		○	○		○	○	○	○	○		○	L/R	L/R	L/R	
public institutions and policies	Washington Convention				○		○				○	(○)	○	○		○	R/G	G	L/R	Effectiveness varies depending on black markets and characteristics of species.
public institutions and policies	Gene bank	○			○		○		○			○		○			R/G	R/G	R/G	Not costly.
public institutions and policies	Seed bank	○			○		○	○	○		○	○		○			R/G	R/G	R/G	
public institutions and policies	Cartagena Protocol on Biosafety						○	○	○	○		○	○	○		○	R/G	R	R	Conflicts among users and managers exist.
public institutions and policies	Regulation of exceptions by the WTO												○				G	R/G	G	Effectiveness varies depending on the exceptions.
public institutions and policies	Environmental impact assessment (EIA) of FTA		○	○									○				R	R	R	Effectiveness varies depending on conditions.

Classification	Institution	Sustainable forest use						Biodiversity conservation				Effectiveness of institutions	Factors relevant to effectiveness							Comments
		Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
public institutions and policies	Kyoto Protocol		○			○	○					(○)	○	(○)	(○)	○	R/G	G	L/R/G	The U.S. has not ratified it. China and India are included in the group of developing countries. There is no consideration of the present forest
public institutions and policies	Biodiversity convention	○	○	○	○	○	○	○	○	○	○	?	○	○			L/R/G	L/R/G	R/G	
public institutions and policies	UN Forestry Forum	○	○	○	○	○	○	○	○	○	○						-	-	-	It has not become a treaty because of conflicts among nations.
public institutions and policies	Criteria and agreement on sustainable forest management	○	○	○	○	○	○	○	○	○	○		○	○			L/R/G	L/R/G	L/R	
public institutions and policies	Forest environmental tax (Japan)	○	○			○				○		(○)	○	○		(○)	L/R	L/R	L/R	The tax will be used to increase ecological services. People who do not manage forests will also gain benefits.
public institutions and policies	Regional environmental tax											○	○	○	(○)	○	L/R	L/R	L/R	The tax will be established at the local government level. Effectiveness varies depending on objects to use.
public institutions and policies	Subsidy for thinning forests	○	○									○	○	○	○		L/R	L/R	L/R	
public institutions and policies	Subsidy for local products and local consumption	○	○	○								○	○	○	○		L	L	L	Scale is small. Motivation of participants should be high. It aims for productive forests.
public institutions and policies	ISO 14001		○									○	○	○	○	○	L	L/R	L	Sustainable forest use and biodiversity conservation are out of scope.
public institutions and policies	Law on promoting green purchasing		○									○	○	○			L/R	L/R	L/R	Sustainable forest use and biodiversity conservation are out of scope.
public institutions and policies	Green owner system	○	○			○						(○)	○	○	○		L/R	L/R	L/R	Not effective after the price of wood declined.
public institutions and policies	Environmental achievement awards											○	—	○	○		-	-	-	Effectiveness varies depending on the award.
public institutions and policies	Environmental education											○	—	○	○		-	-	-	Incentives of users should be increased.

Classification	Institution	Sustainable forest use										Effectiveness of institutions	Factors relevant to effectiveness							Comments
		Provisioning services	Regulating services	Cultural services	Un-substitutable resource conservation	Geographical evenness	Evenness beyond generations	Biodiversity conservation: Genetic diversity	Biodiversity conservation: Stable species composition	Biodiversity conservation: Stable ecosystem	Biodiversity conservation: Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
public institutions and policies	Carbon fund for community development		○			○	○						○	○	○		L/R	G	R/G	It must consider biodiversity. Leakage is possible.
	Academic research											(○)	—	○	○		-	-	-	Effectiveness varies depending on user's incentive.
activities by citizens	Eco-tourism			○	○	○	○				○	(○)	○	○	○		L	L/R/G	L/R/G	The number of users varies depending on the location and facilities.
activities by citizens	Green tourism	○		○		○						(○)	○	○	○		L	L/R	L/R	Cultural resources and facilities are important for success.
activities by citizens	National trust		○	○	○		○	○		○	○	(○)	○	○	○		L	L/R	L/R	Successful collection of funds depends on the site.
activities by citizens	Community forestry, CBM	○	○	○		○	○					(○)	○	○	○	(○)	L/R	L/R/G	L/R/G	Social capital of communities is important.
activities by citizens	Iriai forest management	○	○	○			○					(○)	○	○	○	○	L	L	L	This is the strictest institution, including punishments, in CBM.
activities by citizens	Local objections to forest development	○	○	○	○	○	○	○				(○)		○	○		L	L	L	It is not clear who has the initiative of the objection movement.
activities by citizens	Regional monetary											(○)	○	○	(○)		L	L	L	Effectiveness varies depending on monetary. Product distribution is important to increase users' motivation.
activities by enterprises	CSR																			Companies must be motivated (e.g., by an increased bank rating or improved stock price) as a result of the CSR.
international aid	Establishment of national parks		○	○	○			○	○	○	○	(○)	—	(○)	(○)		R/G	R	R/G	Although incentives for the aid exist, there is little incentive for environmental conservation. Incentives for users are important. Effectiveness varies depending on social conditions. Period of
international aid	Afforestation	○	○									(○)	—	(○)	(○)		R/G	L/R	R/G	
international aid	Assistance for CBM	○	○	○		○						(○)	—	(○)	(○)		L/R/G	L/R	L/R/G	

Classification	Institution	Sustainable forest use										Effectiveness of institutions	Factors relevant to effectiveness							Comments
								Biodiversity conservation												
		Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
international aid	Academic cooperation	○	○	○	○			○	○	○	○	(○)	—	(○)	(○)		R/G	R	R/G	implementation is usually short.
international aid	Cooperation for sustainable forest management	○	○	○	○	○		○	○	○	○	(○)	—	(○)	(○)		L/R/G	L/R/G	L/R/G	
NPOs	Fair trade	○		○		○						○	○	○	○		L	L	L	This institution works effectively only at a small scale.
NPOs	Forest certification	○	○	○	○	○	○	○	○	○	○	○	○	○	(○)	○	L/R	L/R/G	L/R	
NPOs	Objections to loss of forest	○	○	○	○	○	○	○	○	○	○	(○)		○			R/G	L/R/G	R/G	Effectiveness depends on the NPO's capacity
ranking	RDB (Red Data Book)				○		○				○			(○)						Managers are motivated to conserve the area.
ranking	Biodiversity hot spot				○		○				○									Managers are motivated to conserve the area.
thought	Precautionary principal				○		○				○									
thought	Adaptive management	○	○							○										
thought	Social capital	○	○																	
thought	Deep ecology			○			○	○			○									
thought	Access to and sharing the benefits of gene resources	○				○	○													

Remarks） L: village or town level; R: district, state, or national level; G: global level.

2. (○) indicates that the level of effectiveness varies depending on local conditions

Table 2 Characteristics of natural, social, and cultural conditions at the four study sites

Characteristics	Abukuma	Yakushima	Lambir	Sabah	
				Kinabaru	Deramacot
Problems concerning sustainable use of forest and biodiversity	In the Edo era, forests decreased and grassland increased. In the past 100 years, planted coniferous forests have increased drastically.	Loss of primary forests and increase of coniferous forests during the 1960s and 1970s. Nature protection movement in the 1970s. Overuse of natural resources as ecotourism prospers. Agricultural damage by monkeys and deer.	Primary forests have decreased in the past 100 years. Commercial logging from the 1960s and oil palm plantation development from the 1980s have had large effects on the forests. Indigenous people have cut primary forests and created a mosaic landscape with swidden rice fields and fallow forests.	Forests have been conserved since the establishment of the state park in 1964. Farmland near the park has been developed. Golf courses and tourism development have also progressed. Primary forests near the park are facing development pressure.	Since the 1970s, especially in the 1980s, commercial logging was active and most primary forests have disappeared. In the late 1980s, logging was banned and the forest was managed with international aid from GTZ. In 1997, the area was certificated by the FCS.
1. Natural Environment and Land Use					
Climate and vegetation	Temperate deciduous forest.	Warm-temperate rain forest.	Tropical rain forest.	Tropical mountain forest.	Tropical rain forest.
Forest and land use	Reserved forest, “Satoyama” system, natural regeneration practices, man-made forest, and pasture.	Reserved forests, ecotourism, common forests, and man-made forest.	Reserved forests, ecotourism, commercial logging, traditional and modern shifting cultivation, and oil palm plantations.	Reserved forests, ecotourism, commercial logging, man-made forest, and vegetable cultivation.	Commercial logging, forest certification, and low-impact logging.
Characteristics of biodiversity	Logged area up to primary forest. There are no bears and deer.	Relatively high in primary and secondary forests.	Very high in primary forests.	Very high. Fauna and flora varies with altitude.	Same fauna and flora as in mixed dipterocarp forests.
Land use changes	Primary forests, secondary forests, grassland, and man-made forest	See the changes listed in (1).	Primary forests have been converted to swidden fields, logged areas, plantations, and urban areas.	See the changes listed in (1).	See the changes listed in (1).
2. Social Environment					
Effectiveness of regulations on forest conservation	Relatively high.	Relatively high.	Relatively high as compared with neighboring countries.	Relatively high as compared with neighboring countries.	Relatively high as compared with neighboring countries.
Government organizations concerning policy, forests, and land use	Government, Ministry of Agriculture, Forestry and Fishery, Forestry Agency, and national forest.	Forestry agency, ministry of environment, and cultural affairs agency.	State government (forestry department and ministry for land development).	State government (Sabah Park).	State government (forestry department).
Policy and institutions on forest development	Forest Law, Forestry Basic Law, and prefectural park.	Transferred to national forest category (1889), national forest management plan (1923), and large-scale afforestation (1960s).	Forestry regulations, commercial logging system, national park law, land calcifications and NRC, and a license required for plantation development.	Commercial logging can be practiced in the part of the forest designated as a Class II Commercial Forest Reserve.	Commercial logging can be practiced in the part of the forest designated as a Class II Commercial Forest Reserve.
Policy and institutions on forest conservation	Protected forests, conserved forests, and prefectural parks.	The Yaku-sugi primary forest was designated as a National Treasure (1924) and a National Park (1964), and was an original nature conservation area. Construction of the west forest road was stopped (1999).	National park, protection of indigenous territory, and no ecotourism.	State park and World Heritage Site (2001).	Forest certification (FSC).
Effectiveness of policies	High.	High.	Relatively high as compared with neighboring countries.	Relatively high as compared with neighboring countries.	Relatively high as compared with neighboring countries.
NPOs practice forest conservation	Not very active.	Important for forest conservation.	Not active as compared with neighboring countries.	No activity.	Forest certification (FSC).
Local forest uses	Employment, grazing, and NFTP use.	Iriai system and cooperative management in coniferous plantations were seen before.	On land with native rights, the land can be used freely. On state land, land use has drastically changed.	The protected area cannot be used. Indigenous people have the right to use land around the park. In a part of these areas, forests are protected for water conservation, and sustainable timber production is observed there.	For forest certification, local use of the forest must be monitored. Local people must be employed for forest management. Traditional land use is allowed in a part of the territory.

Characteristics	Abukuma	Yakushima	Lambir	Sabah	
				Kinabaru	Deramacot
Social problems in rural areas	Depopulation and aging.	Depopulation of villages accelerated in the 1960s, but it stopped during the 1990s.	Depopulation is progressing in the middle and upper parts of the river basin.	Agricultural land has decreased as the population has increased.	Logging is the only way to earn money.
3. Economic Environment					
Forest resources and global economy	Economic growth in Japan and increase of planted coniferous forests following afforestation policy.	Coniferous afforestation was a failure due a changing global economy after the 1970s.	Forest uses, such as commercial logging and plantation development, have drastically changed as the global economy has changed.	Land use out of the park has changed following global economic conditions.	Forest resources have largely decreased because of a large global demand for timber.
Forest resources and national economy	Low price of pulp and timber.	Same as above	Government drives forest development policies relating to the global economy.	Government drives forest development policies relating to the global economy.	Unbalanced government budget between federal and state. The state budget depends heavily on natural resources.
Forest resources and enterprises	Retreatment of pulp company, and then ingress of lumber company.	Pulp industry logged broadleaf forests.	Private companies developed forests for commercial logging and plantation development following global economic trends.	Private companies developed forests for commercial logging and plantation development following global economic trends.	Forests were logged by companies that had concessions with short periods.
Forest resources and regional economy	Forest uses have changed as follw: 1. grazing, 2. carbon making, 3 .pulp tip and 4. mushroom cultivation	The timber industry was previously the main industry, but tourism currently is.	Rubber and pepper are widely cultivated as cash crops.	Primary forests and biodiversity are observed as sustainable resources. A large amount of income is derived from park entrance fees.	About 70% of state government income was generated from the forest industry in the 1980s.
Forest resources and rural economy	Local people were previously employed as workers in national forests. Today, forest cooperation only works. Wood for mushroom	Same as above.	Wage work at logging camps. Rice production for workers in logging camps.	Many villagers are employed as rangers and workers for the park. Many villagers also work for the tourism industry.	Local people are employed for afforestation work in sustainable forestry management.
4. Cultural Environment					
Ethnicity	Japanese, who immigrated after World War II.	Original inhabitants and immigrants (such as for tourist guides).	Iban (indigenous people), Chinese, and mixed-race people (Malay and Iban) living in urban areas.	Dusun (indigenous people).	Orang Sungai (indigenous people).
Local forest uses	Collection of mushrooms, edible fungi, and fallen leaves as fertilizer. Wood for mushroom cultivation.	No current traditional uses. Current forest products are used for souvenirs and firewood for drying mackerel. Houses are built using Sugi wood.	Forest resources are still used, although it has declined. Swidden agriculture is still important. Hunting, fishing, and collecting forest products are important.	Forest uses are declining, although local people still practice hunting and collect forest products. Sawmills produce wood for construction of houses.	Collected forest products and fish from nearby rivers for self-consumption are still very important.
Spiritual relationship between local people and the forests	Almost none.	Local people still spiritually depend on the forests. There are rituals concerning forest spirits.	The existence of forests is connected with agricultural rituals and the value of life and death.	Kinabaru Mountain was formerly a sacred place. The influences of Christianity and modernism have reduced such recognition.	Forests were strongly connected to ritual practices and spiritual values.
Forest management at the community level	Wood for mushroom cultivation is from national forests. Thinning is practiced in parts of private forests. Grasslands were previously managed as common land, but they are now owned privately. Foresters formerly lived near villages, and opinions from villagers were given to the officers.	Forests were managed cooperatively in common forests and in private forests.	There are no strong institutions, but there are informal rules, which change depending on prevailing social and economic conditions.	There is a common forest, which serves as a water supply, and the timber is sustainably produced there.	There is a 15-ha community forest in the reserve, and traditional forest uses by five villages are allowed there. Forest uses in the other areas are not allowed.

Table 3 (1) Evaluation of institutions for sustainable forest use and biodiversity (Abukuma)

Institution	Sustainable forest use										Effectiveness of institutions	Factors relevant to effectiveness							Comments
							Biodiversity conservation												
	Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
Protected forest by Forest Agency of Japan		○	○	○		○	○	○	○	○	○	○		(○)	○	R	L/R	R	
National Forest Management Plan	○	○					(○)	(○)	(○)	(○)	(○)	○	(○)			L/R	L/R	R	Bureaucratic organization is not effective. Managers' incentives vary depending on whether the forest is productive or non-productive.
Community forestry, CBM	(○)	(○)	(○)		(○)	(○)					(○)	○	(○)	(○)	(○)	L	L	L	Management is loosely cooperative. Depopulation and aging in the community are serious problems.
Forest uses in the Satomi community	(○)	(○)	(○)		(○)						(○)	○	(○)	(○)		L	L	L	Villagers hope that some areas become artificial forests.
The prefectural park is designated as an RDB				○		○				○	(○)		○						
Iriai forest management	(○)					(○)					(○)	(○)			(○)	L	L	L	The area previously had commonly owned Iriai grasslands, but they have been divided into privately owned plots in the past 10 years.
Academic research	○	○		○			○	○	○	○	(○)	–	○	○		-	-	-	Effectiveness varies depending on users' needs.

Remarks) L: village or town level; R: district, state, or national level; G: global level.

2. (○) indicates that the level of effectiveness varies depending on local conditions

Table 3 (2) Evaluation of institutions on sustainable forest uses and biodiversity (Yakushima)

Institution	Sustainable forest use: Provisioning services	Sustainable forest use: Regulationg services	Sustainable forest use: Cultural services	Sustainable forest use: Un-substitutable resource conservation	Sustainable forest use: Geographilcal evenness	Sustainable forest use: Evenness beyond generations	Biodiversity conservation: Genetic diversity	Biodiversity conservation: Stable species composition	Biodiversity conservation: Stable ecosystem	Biodiversity conservation: Biological uniqueness and rarity	Effectiveness of institutions	Factors relevant to effectiveness: Distinctiveness of the right	Factors relevant to effectiveness: Incentives for governors and/or managers	Factors relevant to effectiveness: Incentives for users	Factors relevant to effectiveness: Punishment	Factors relevant to effectiveness: Scale of managers	Factors relevant to effectiveness: Scale of users	Factors relevant to effectiveness: Scale of cost payer	Comments
National park		○	○	○		○	○	○	○	○	○	○	○		○	L/R	L/R/G	R	
National Forest Management Plan		○	○	○		○	○	○	○	○	○	○				R	L/R	R	
World Heritage			○	○		○				○	○	(○)	○	○	○	L/R	L/R/G	L/R	
Ramsar Convention						○	○		○	○	(○)		○			L/R/G	L/R/G	L/R/G	
Natural Treasure (place)			○	○		○				○	○	○	○	(○)	○	L/R	L/R	L/R	
Biodiversity hot spot				○		○				○									
Prevention of intrusion of exotic species	○	○	○	○		○	○	○	○	○	○	–	○		○	L/R	L/R	L/R	
Natural Treasure (species)			○	○		○		○		○	○	○	○		○	L/R	L/R	R	
Act of species protection				○		○	○	○		○	○	○	(○)		○	L/R	L/R	L/R	
Eco-tourism			○	○	○	○				○	(○)	○	○	○		L	L/R/G	L/R/G	
Satoyama conservation areas	○	○	○			○				○	?	○	(○)	(○)		L	L/R	L/R	The effectiveness is not yet known because the system has just begun.
Subsidies to lower mountainous regions	○	○	○				○		○		?	○	(○)	(○)		L	L/R	L/R	The effectiveness is not yet known because the system has just begun.
NPO objection to forest loss	○	○	○	○	○	○	○	○	○	○	(○)		○	○		R/G	L/R/G	R/G	
Local objection to forest development	○	○	○	○	○	○	○				(○)		○	(○)		L	L	L	
Green tourism	○		○		○						(○)	○	○	○		L	L/R	L/R	
Iriai forest management	○	○	○			○					(○)	○	○	(○)	(○)	L	L	L	The frequency of forest uses has decreased.

Subsidies for thinning	○	○									○	○	○	(○)	(○)	L/R	L/R	L/R	
Subsidies for local products and local consumption	○	○	○								○	○	○	○		L	L	L	
Academic research											(○)	–	○	○		–	–	–	
Environmental education											○	–	○	○		–	–	–	

Remarks) L: village or town level; R: district, state, or national level; G: global level.

2. (○) indicates that the level of effectiveness varies depending on local conditions

Table 3 (3) Evaluation of institutions on sustainable forest uses and biodiversity (Sabah)

Institution	Sustainable forest use										Effectiveness of institutions	Factors relevant to effectiveness							Comments
							Biodiversity conservation												
	Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
Kinabaru Mountain																			
State park		○	○	○		○	○	○	○	○	○	○	○	○	○	L/R	L/R/G	L/R/G	
Environmental tax (fee for entrance and mountain climbing)		○	○	○		○	○	○	○	○	○	○	○		○	L/R	L/R	L/R	The fees are used for park maintenance.
World Heritage			○	○		○	○	○	○	○	○	○	○	○	○	L/R	L/R/G	L/R/G	Since 2000, there has been an overuse problem.
Eco-tourism			○	○	○	○				○	(○)	○	○	○		L	L/R/G	L/R/G	Many tourists are only interested in mountain climbing.
Local environmental education											○	—	○	○		-	-	-	Since the 1980s, educators have stressed that forest protection is important for local residents' livelihood.
Community forest management	○	○	○			○					(○)	○	(○)	(○)	○	L	L	L	It works for forest conservation outside of the park and is good for provisioning services.
Academic research											○	—	○	○		-	-	-	Research contributed to the designation as a World Heritage Site.
Deramacot																			Productive forest area for timber.
Criteria and agreement for sustainable forest	○	○	○	○	○	○	○	○	○	○		○	○			L/R/G	L/R/G	L/R	
Forest certification (FSC)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	L/R	L/R/G	L/R	The incentive for sustainable forest management increased as a result of the introduction of a 90-year concession.
International aid for sustainable forest uses	○	○	○	○	○		○	○	○	○	○	—	(○)	○		L/R/G	L/R/G	L/R/G	
Local environmental education	○		○								○	—	○	○		-	-	-	It was required for FSC. Some communities do not reside in the productive forest area.
Kyoto Protocol		○			○	○					(○)	○	(○)	(○)	○	R/G	L/R/G	L/R/G	FSC forests should be considered under the protoco.
Biodiversity convention	○	○	○	○	○	○	○	○	○	○	?	○	○			L/R/G	L/R/G	R/G	

Remarks〉 L: village or town level; R: district, state, or national level; G: global level.

2. (○) indicates that the level of effectiveness varies depending on local conditions

Table 3 (4) Evaluation of institutions on sustainable forest uses and biodiversity (Lambir, Sarawak)

Institution	Sustainable forest use										Effectiveness of institutions	Factors relevant to effectiveness							Comments
							Biodiversity conservation												
	Provisioning services	Regulationg services	Cultural services	Un-substitutable resource conservation	Geographilcal evenness	Evenness beyond generations	Genetic diversity	Stable species composition	Stable ecosystem	Biological uniqueness and rarity		Distinctiveness of the right	Incentives for governors and/or managers	Incentives for users	Punishment	Scale of managers	Scale of users	Scale of cost payer	
Lambir National Park		○		○		○	○	○	○	○	○	○	○	(○)	○	R	L/R/G	R	Well managed, although small-scale illegal logging is sometimes done.
Biodiversity hot spot				○		○				○									
Species conservation law				○		○	○	○		○	(○)	○	○		○	L/R	L/R	L/R	
Washington Convention				○		○				○	○	(○)	○		○	R/G	G	L/R	
Eco-tourism			○	○	○	○				○		○	○	(○)		L	L/R/G	L/R/G	Just in small scale. Little economic contribution to local communities
NPO objection to logging	○	○	○	○	○	○	○	○	○	○	(○)		○	(○)		R/G	L/R/G	R/G	Not significant around Lambir.
Local objection to logging	○	○	○	○	○	○	○				(○)		○	○		L	L	L	Oil palm plantations are developed around Lambir.
International cooperation for afforestation	○	○									(○)	–	○	(○)		R/G	L/R	R/G	Only a pilot project for small research level.
Environmental education											○	–	○			–	–	–	Small trial only in the park.
Land use by indigenous people	○	○	○		○	○					(○)	○	○	○	(○)	L/R	L/R/G	L/R	Land use is secondary-forest based and in transition.

Remarks) L: village or town level; R: district, state, or national level; G: global level.

2. (○) indicates that the level of effectiveness varies depending on local conditions